Blast Barrier Effectiveness Simulations

Presented by

Tommy L Bevins

At

High Performance Computing Modernization Program

Users Group Conference 2001

Biloxi, MS

Overview

- **Background**
  - **Needs for analysis**
  - **Experiments**
- **Analysis methodology and code scalability**
  - **Scalability**
  - **Mesh size analysis**
  - **Final mesh**
  - **Experimental comparisons**
- **Improvements to CTH**
  - **AMR**
  - **Rigid nclusions**
- **Conclusions**

**US Army Corps
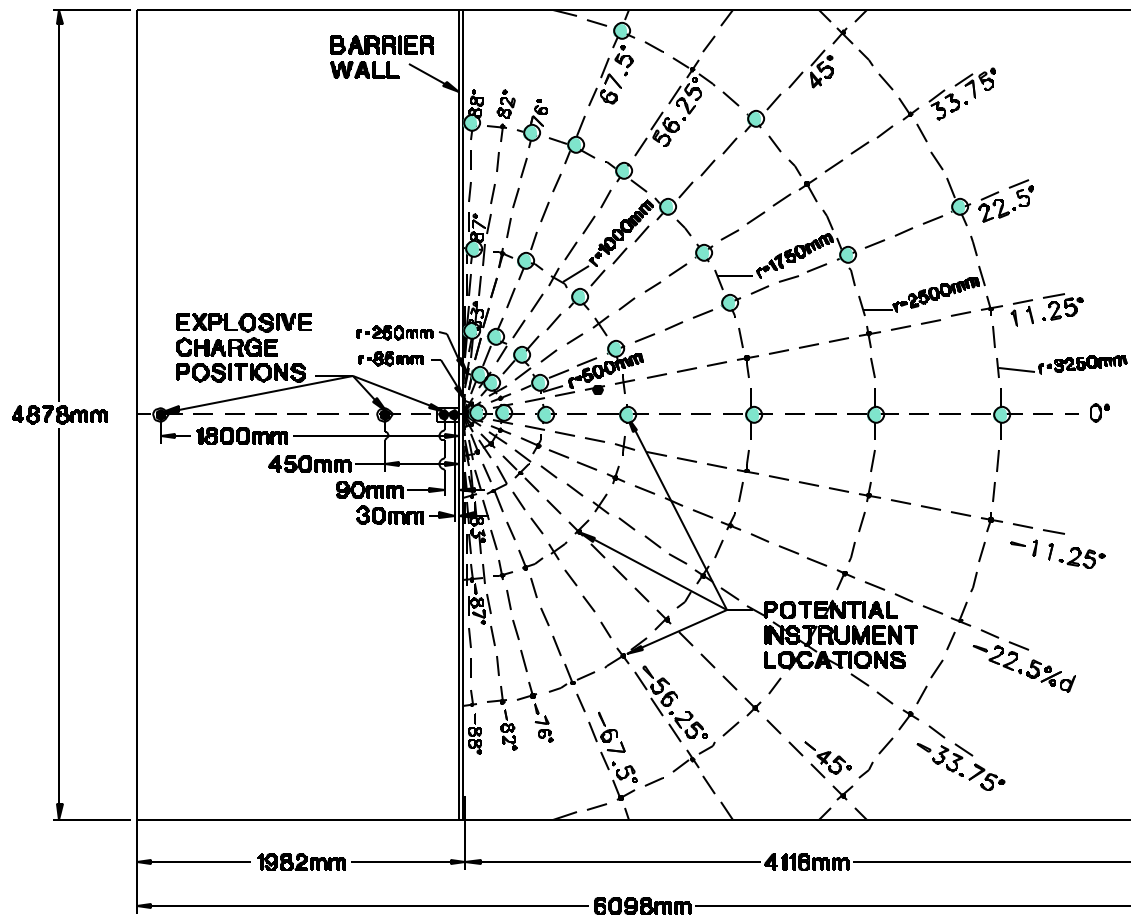of Engineers**

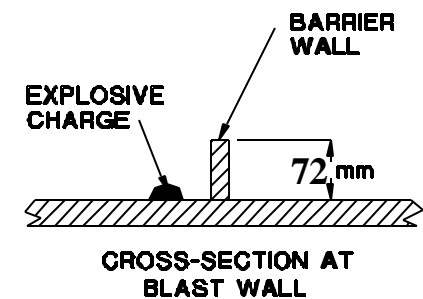**Engineer Research and Development Center**

Background

- **S&PS research program is focused on the warfighter's needs for force protection and counter-terrorist threats.**

- **Need to provide engineering tools to allow rapid evaluation of the effectiveness of counter-terrorism technology.**

- **ERDC has conducted a series of small-scale blast-barrier experiments.**

- **Use analytical approach to increase our understanding of the experimental data.**
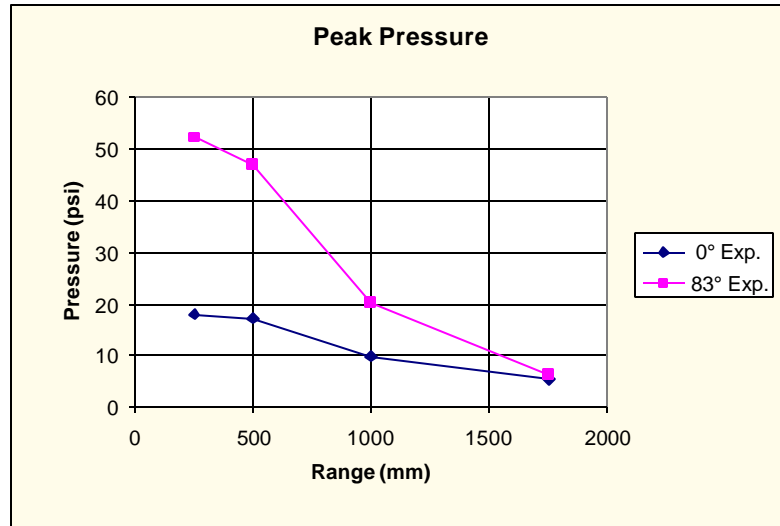
PLAN VIEW

1:50 BARRIER WALL EXPERIMENTS

Experimental Data

Peak Pressure

Reasons for Computations:

- **Why is the benefit of the blast wall so much greater along the zero degree azimuth?**

- **Test data presents a good opportunity to verify analysis code.**

- **Validated simulations will be used to understand and design blast walls.**

Analysis Approach

- Background
  - Needs for analysis
  - Experiments
- **Analysis methodology and code scalability**
  - **Scalability**
  - **Mesh size analysis**
  - **Final mesh**
  - **Experimental comparisons**
- Improvements to CTH
  - AMR
  - Rigid Inclusions
- Conclusions

US Army Corps of Engineers

Engineer Research and Development Center

Analysis Methodology and Code Scalability

- **Use CTH to predict airblast.**
  - **CHSSI**
  - **Scalable**
  - **Eulerian shock physics code**
- **Show scalability on current systems.**
- **Optimize cell size for runtime and numerical error.**

Systems for Scalability Study

	T3E	Osprey (IBM SP)	Pandion (IBM SP)	Origin
Processor Type	Alpha	P2SC	POWER2	R10000
Number of Processors	544	255	126	112
Processor Speed	600 MHz	135 MHz	160 MHz	195 MHz
Total Gflops	634	137.7	80.6	49.9

CTH Scalability
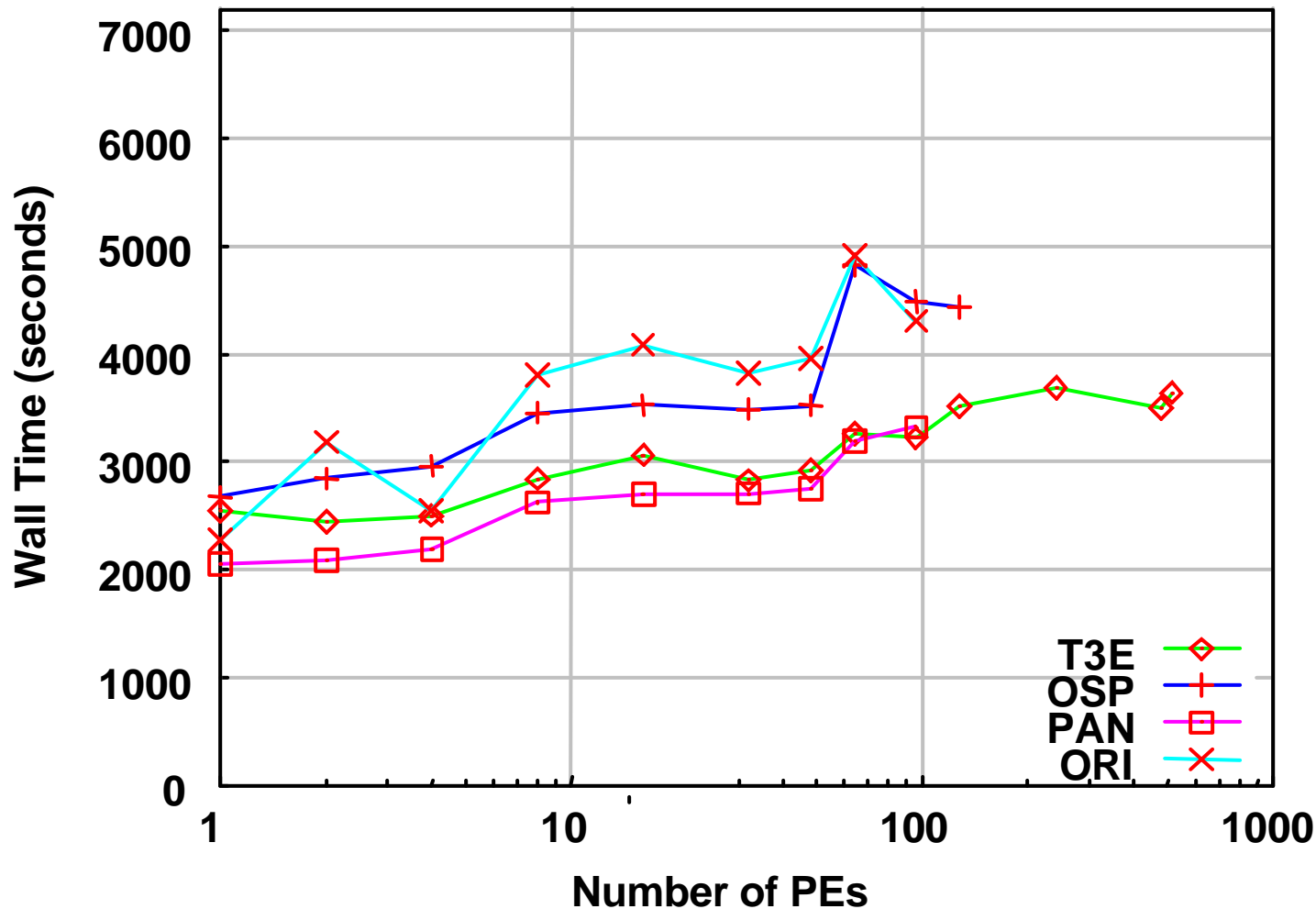
T3E

512 X Size
1.5 X Time

Pandion

100 X Size
1.57 X Time

US Army Corps
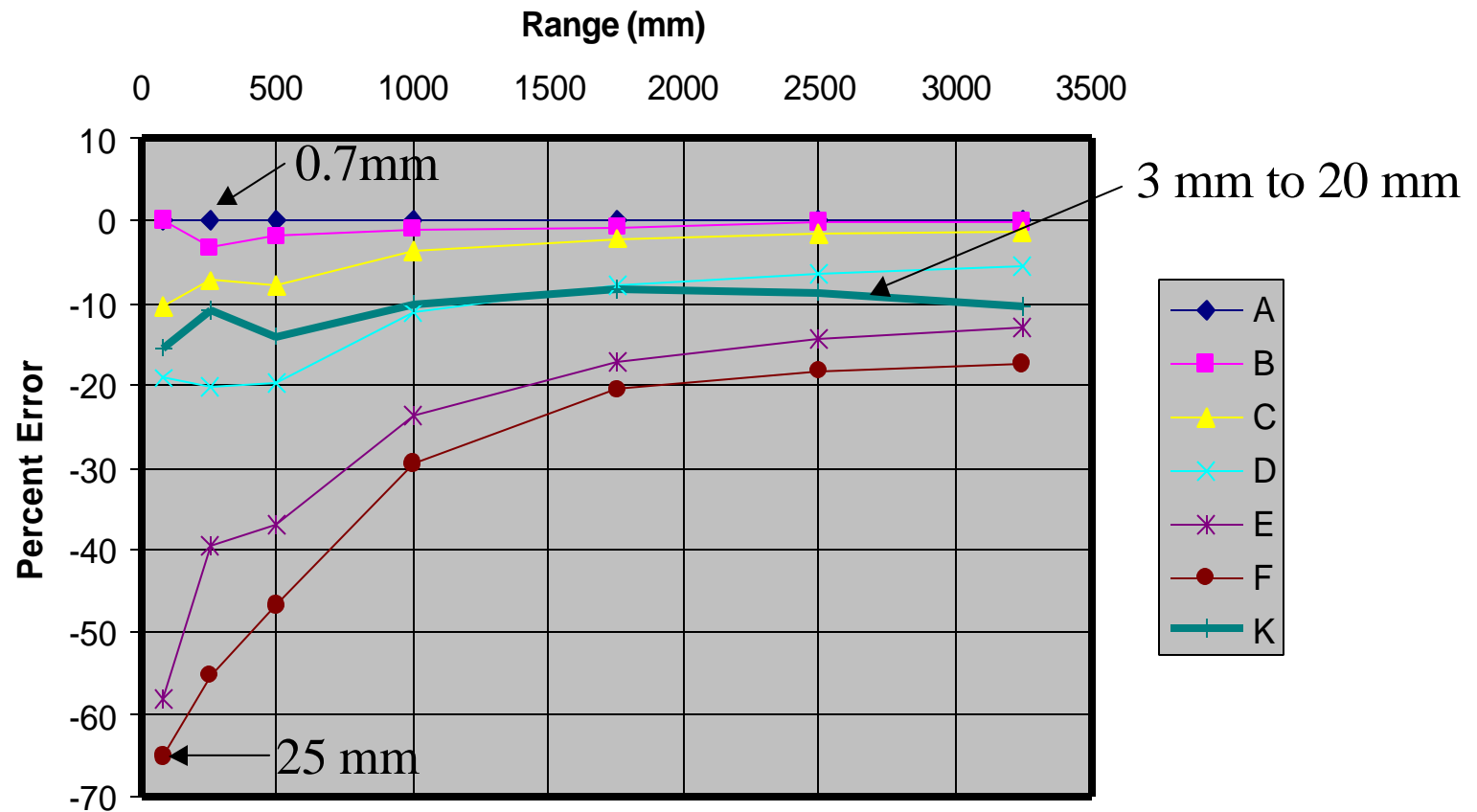of Engineers

Engineer Research and Development Center

Cell Size Optimization

- **Initially use 1-D spherical analysis**
  - **Starting cell spacing is 2.5 cm**
  - **Decrease by ½ until minimal changes in pressure and impulse**
  - **Limit peak pressure error to approximately 10%**
  - **Limit peak impulse error to approximately 5%**
  - **Use variable spaced mesh to accommodate error limits**
- **Check with 2-D and 3-D analysis**
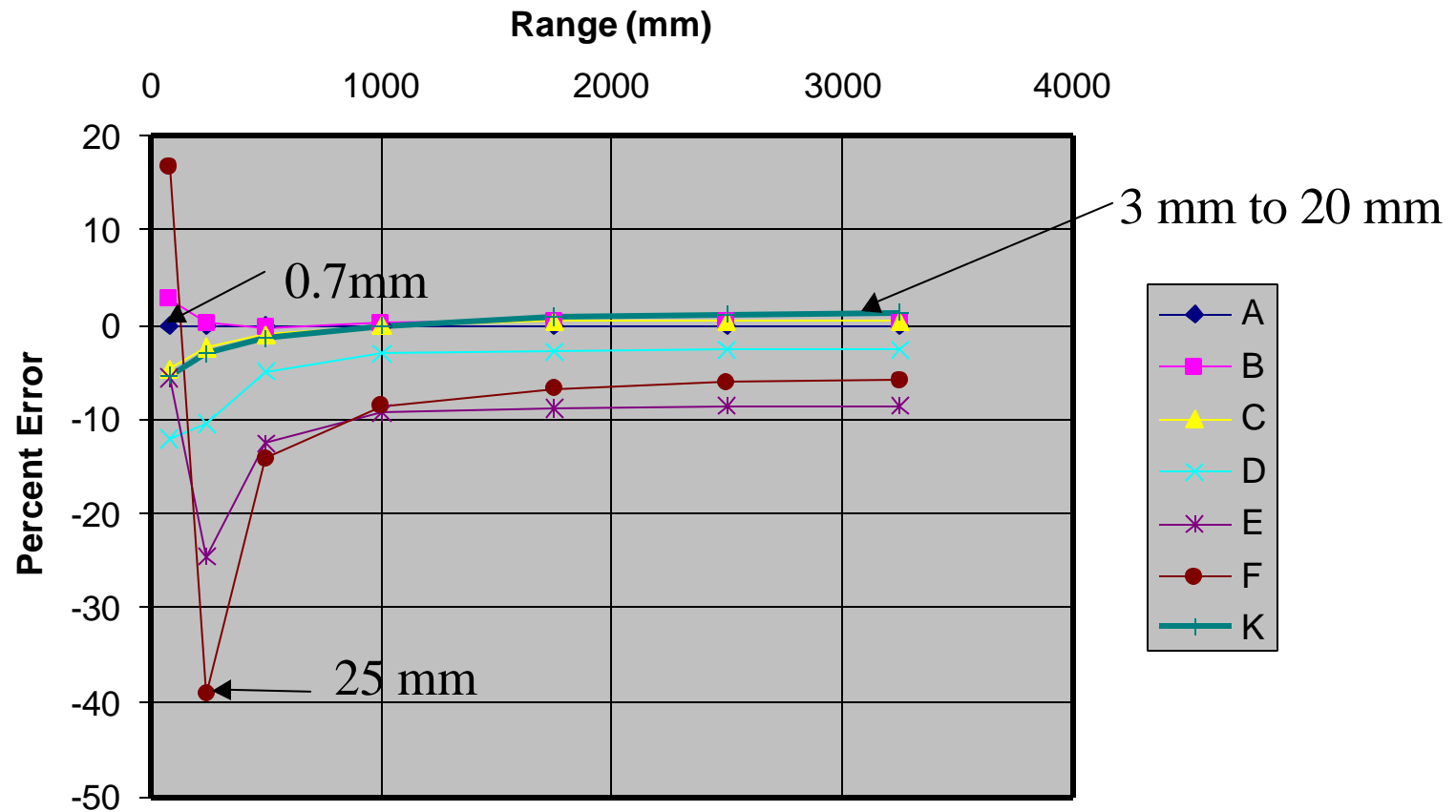- **Compare to control experiments (free-field)**

Peak Pressure Error, 1-D Simulations

US Army Corps
of Engineers

Engineer Research and Development Center
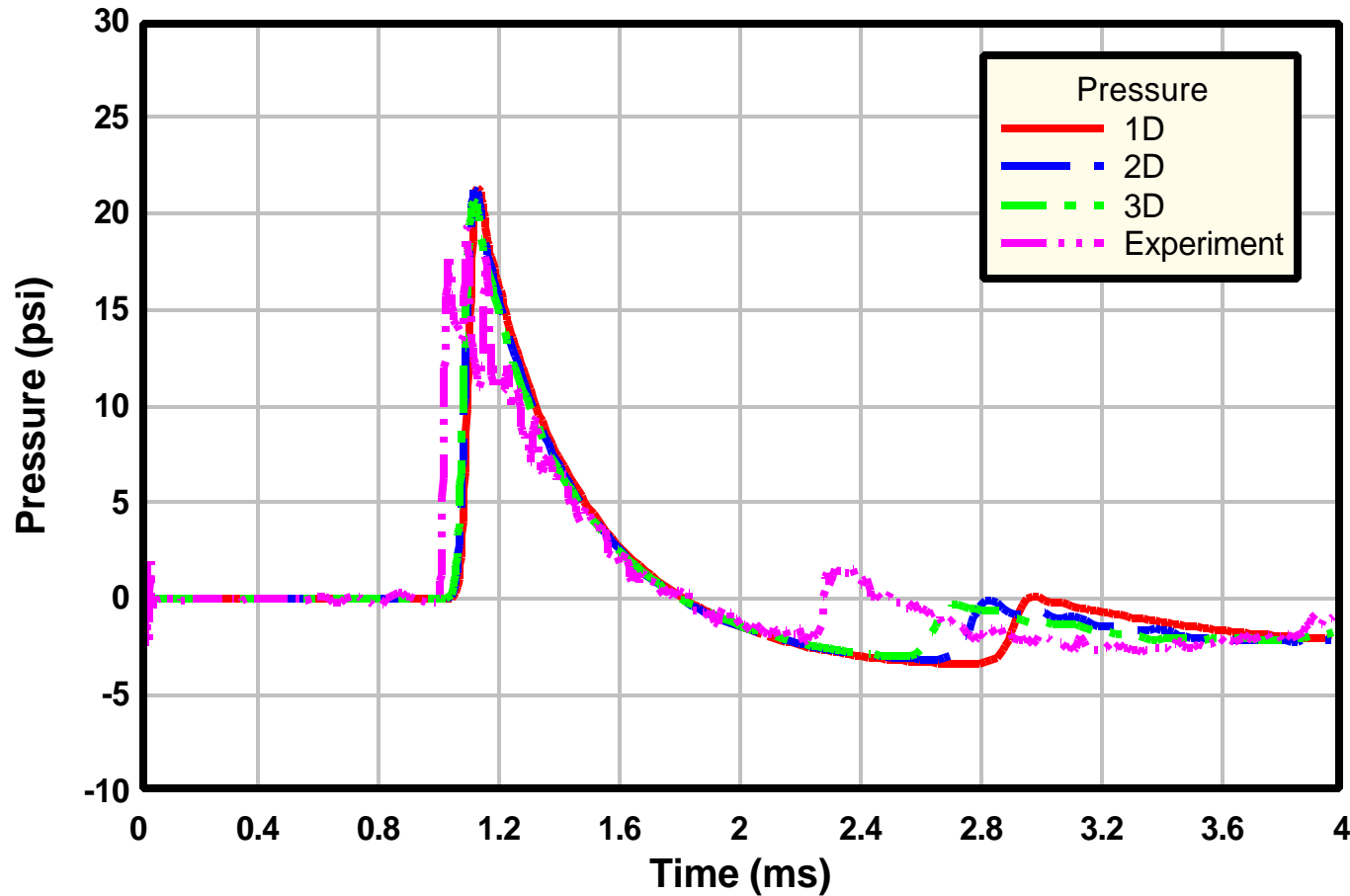
Impulse Error, 1-D Simulations

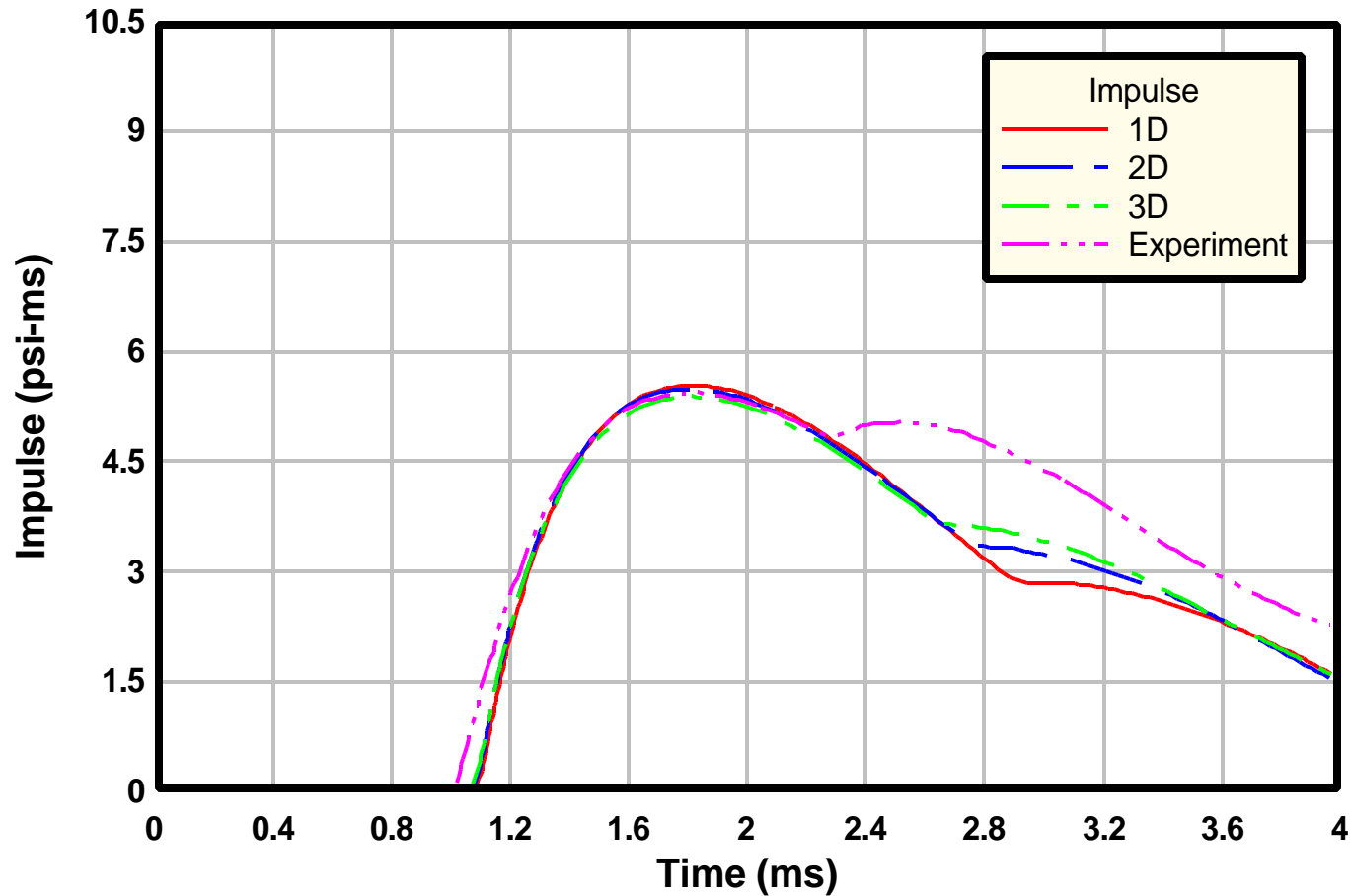# *Pressure, 1-D, 2-D, 3-D Verification*

Gage 25
Range = 100 cm

US Army Corps
of Engineers

Engineer Research and Development Center

Impulse, 1-D, 2-D, 3-D Verification
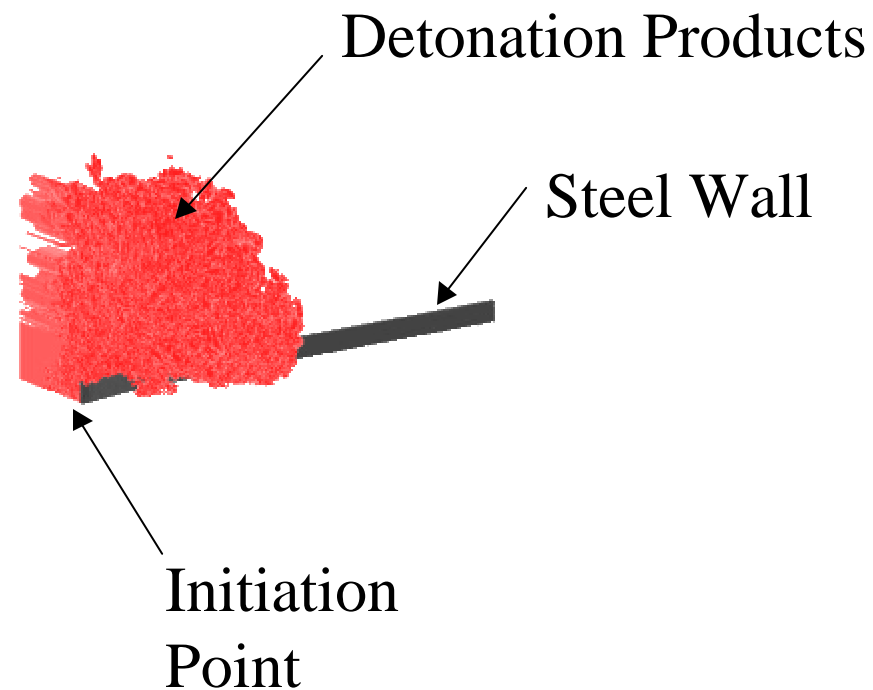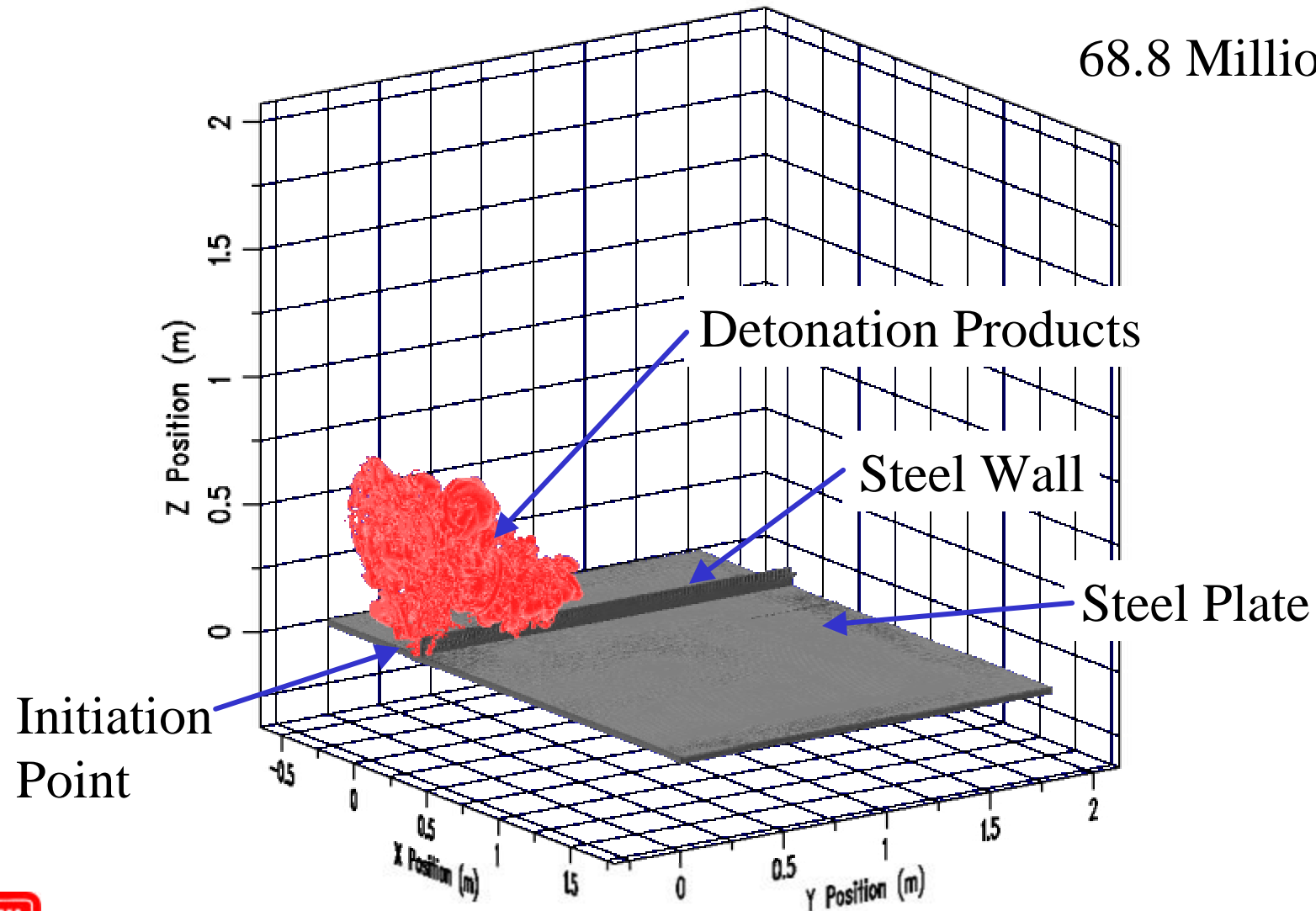
Gage 25
Range = 100 cm

Detonation Products

Steel Wall

Initiation
Point

68.8 Million Cells

Detonation Products

Steel Wall

Steel Plate

Initiation
Point

Z Position (m)
X Position (m)
Y Position (m)

Experimental Gage Locations
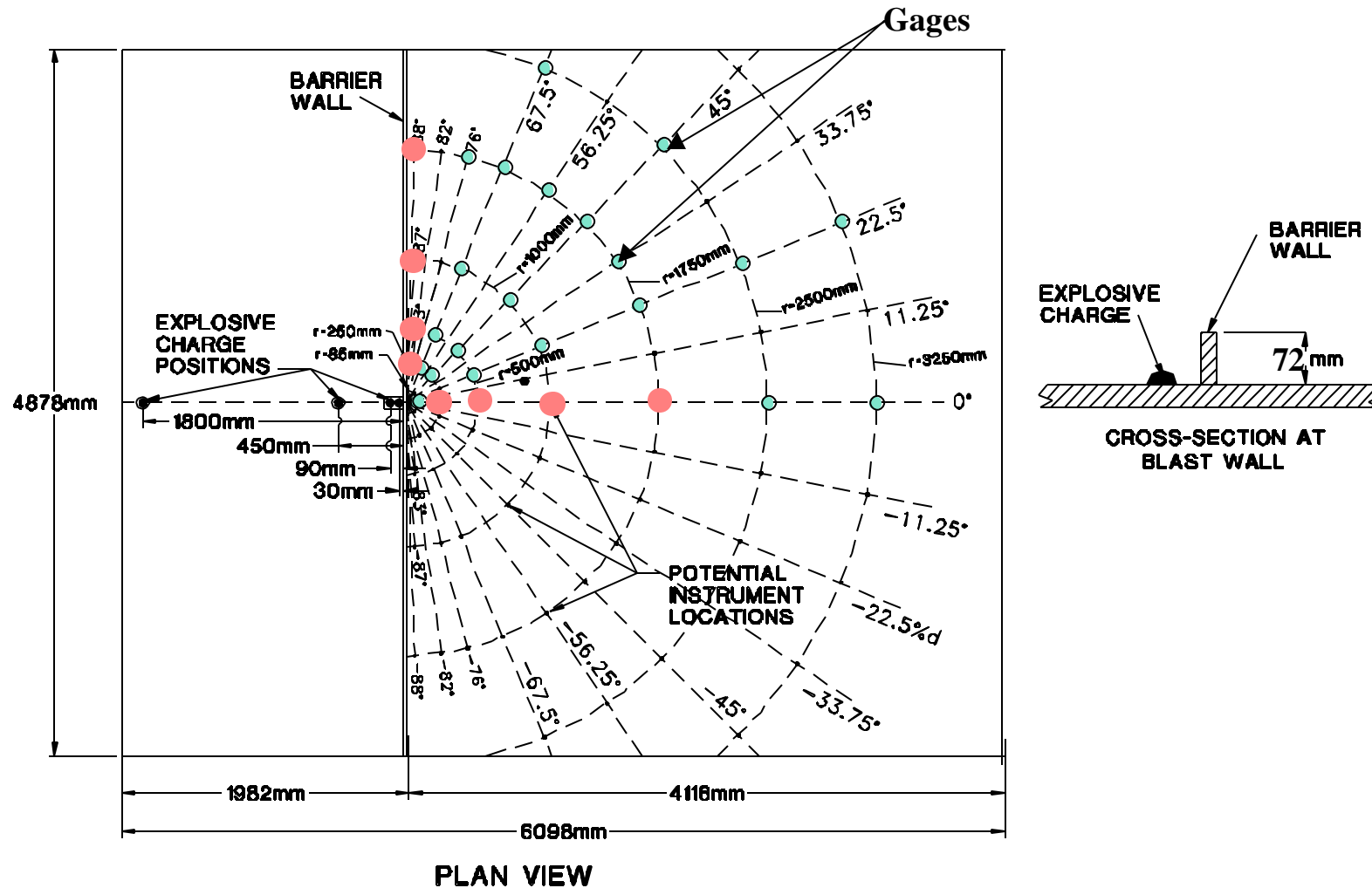
PLAN VIEW

1:50 BARRIER WALL EXPERIMENTS

Comparisons with Blast Wall Experiments

Gage 15
Range=500 mm
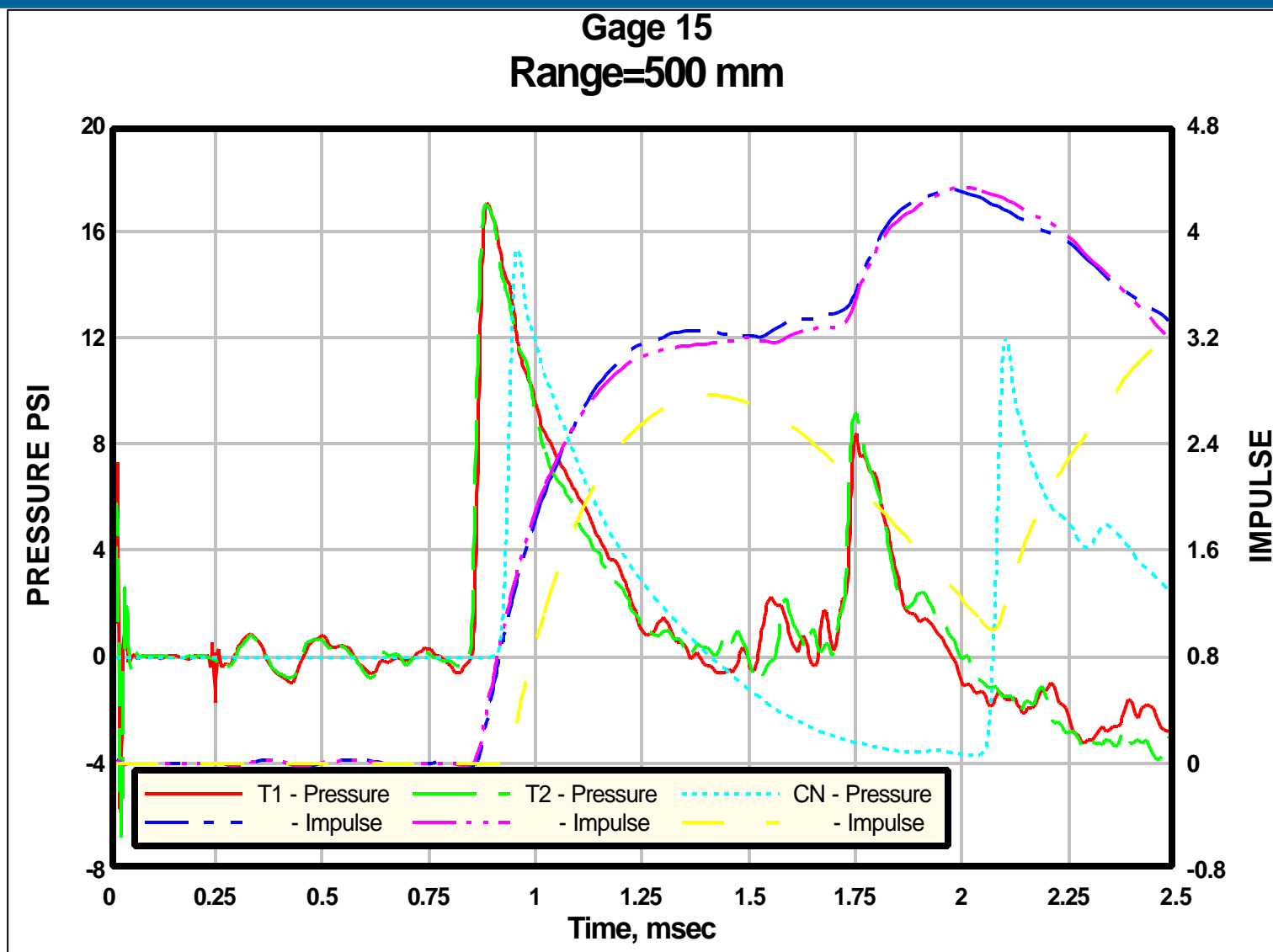
Peak Pressure Comparisons
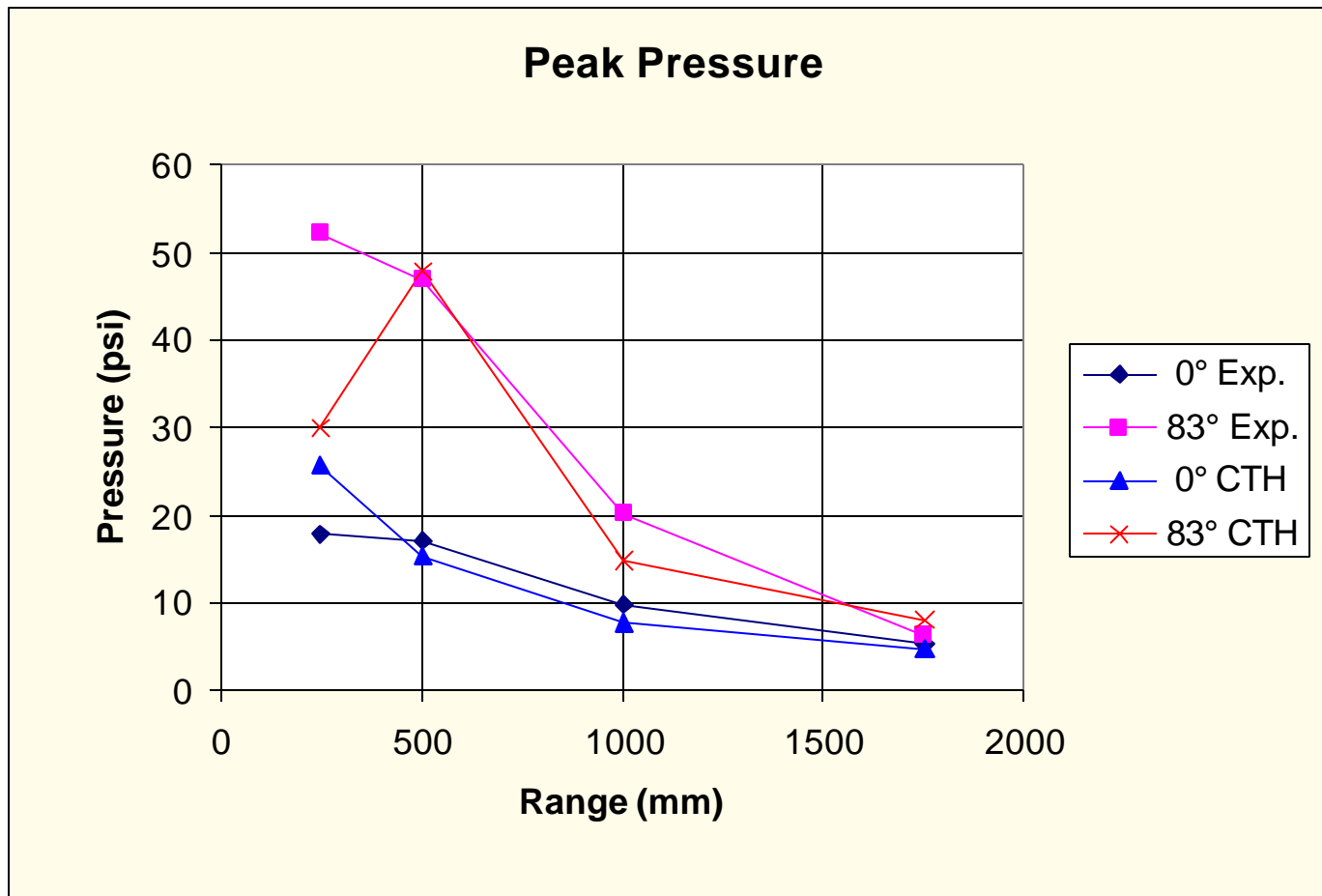
Peak Impulse Comparisons

Peak Impulse
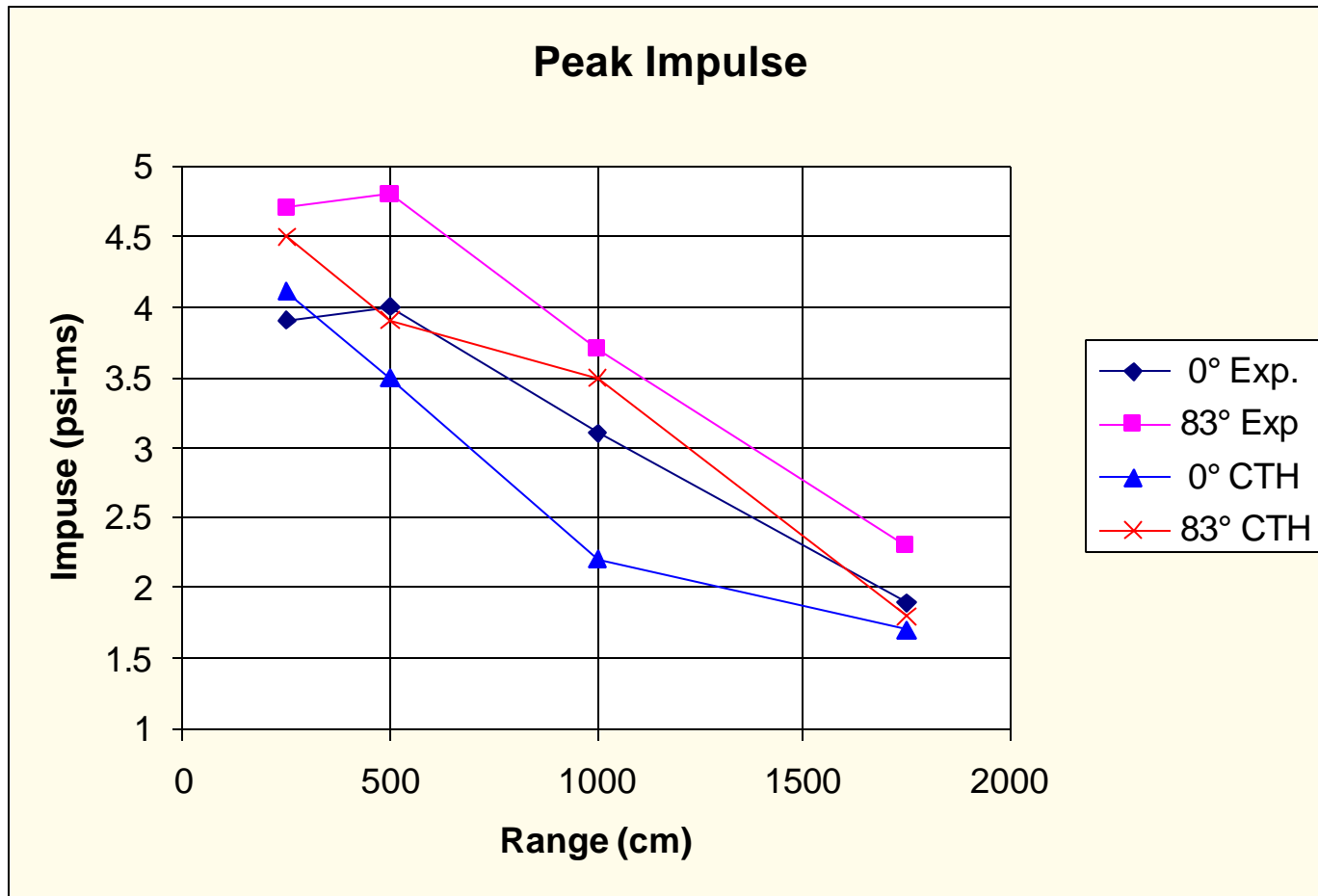
Improvements

- Background
  - Needs for analysis
  - Experiments
- Analysis methodology and code scalability
  - Scalability
  - Mesh size analysis
  - Final mesh
  - Experimental comparisons
- **Improvements to CTH**
  - **AMR**
  - **Rigid inclusions**
- Conclusions

- **Automatic Mesh Refinement (AMR)**
  - **Littlefield, TICAM**
  - **Refine and coarsen cell spacing as needed**
    - **Reduces the active mesh size**
- **Rigid inclusions**
  - **Littlefield, TICAM**
  - **Remove solid material EOS when possible**
    - **Usually will increase DT**

Initial AMR Checks

| PE's	AMR	Time
1	NO	2040
1	YES	626
8	YES	226
8	NO	340

Initial Rigid Inclusion Checks

- **Reduced blast wall mesh**
  - 3.8 Million Cells
- **Run for 10 hours wall time on 8 processors**
- **Rigid inclusion**
  - Simulated 0.5 ms
- **Steel material**
  - Simulated 0.3 ms
- **Net improvement in simulated problem time of 67% for rigid material**
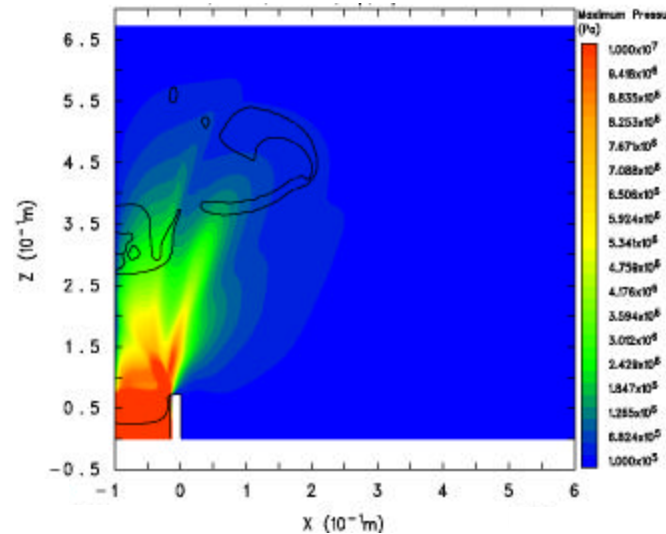 - Rigid inclusion increased DT as expected

Rigid Inclusion/Steel Wall Problem Setup
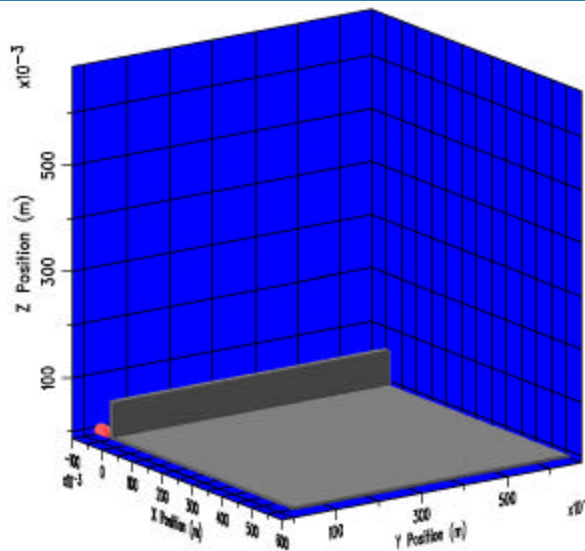
Steel Wall and Base
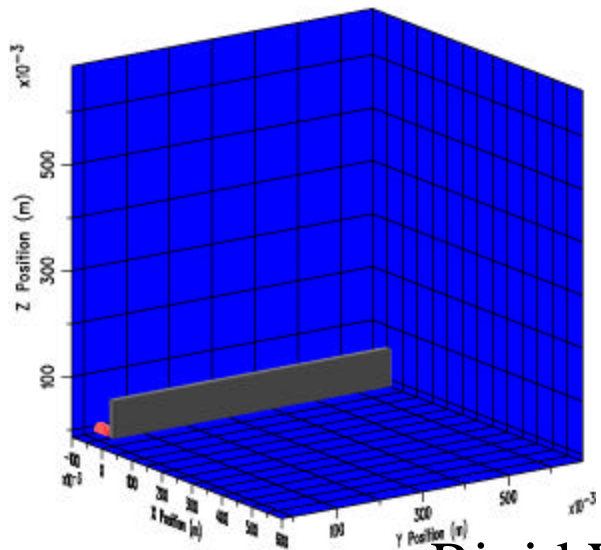
Rigid Wall and Reflective Base

Conclusions

- **CTH reproduces experimental results.**

  - **Results are being used to understand phenomenology near blast walls.**

  - **Analysis requires extensive HPC resources provided under the challenge projects.**

- **Enhancement offer significant improvements to analysis times.**

  - **AMR offers a net improvement of 33%**

  - **Rigid inclusions offers an improvement of 67%**